

## Answers to Review for Quiz: Acids, Bases and Salts

1. Acids are proton **donors**. Complete the following chart for these **acids**:

Acid	Ionization Reaction in Water	Conjugate Base	Ka	Kb
H <sub>2</sub> SO <sub>3</sub>	H <sub>2</sub> SO <sub>3</sub> (l) + H <sub>2</sub> O (l) ↔ HSO <sub>3</sub> <sup>1-</sup> (aq) + H <sub>3</sub> O <sup>+</sup> (aq)	HSO <sub>3</sub> <sup>1-</sup>	1.4 x 10 <sup>-2</sup>	7.1 x 10 <sup>-13</sup>
HCHO <sub>2</sub>	HCHO <sub>2</sub> (l) + H <sub>2</sub> O (l) ↔ HCO <sub>2</sub> <sup>1-</sup> (aq) + H <sub>3</sub> O <sup>+</sup> (aq)	HCO <sub>2</sub> <sup>1-</sup>	1.8 x 10 <sup>-4</sup>	5.6 x 10 <sup>-11</sup>
HPO <sub>4</sub> <sup>2-</sup>	HPO <sub>4</sub> <sup>2-</sup> (aq) + H <sub>2</sub> O (l) ↔ PO <sub>4</sub> <sup>3-</sup> (aq) + H <sub>3</sub> O <sup>+</sup> (aq)	PO <sub>4</sub> <sup>3-</sup>	4.8 x 10 <sup>-13</sup>	2.1 x 10 <sup>-2</sup>
H <sub>2</sub> O	H <sub>2</sub> O (l) + H <sub>2</sub> O (l) ↔ OH <sup>1-</sup> (aq) + H <sub>3</sub> O <sup>+</sup> (aq)	OH <sup>1-</sup>	1.0 x 10 <sup>-14</sup>	1.0
NH <sub>4</sub> <sup>1+</sup>	NH <sub>4</sub> <sup>+</sup> (aq) + H <sub>2</sub> O (l) ↔ NH <sub>3</sub> (aq) + H <sub>3</sub> O <sup>+</sup> (aq)	NH <sub>3</sub>	5.6 x 10 <sup>-10</sup>	1.8 x 10 <sup>-5</sup>
HCO <sub>3</sub> <sup>1-</sup>	HCO <sub>3</sub> <sup>1-</sup> (aq) + H <sub>2</sub> O (l) ↔ CO <sub>3</sub> <sup>2-</sup> (aq) + H <sub>3</sub> O <sup>+</sup> (aq)	CO <sub>3</sub> <sup>2-</sup>	4.7 x 10 <sup>-11</sup>	2.1 x 10 <sup>-4</sup>
H <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub> (l) + H <sub>2</sub> O (l) → HSO <sub>4</sub> <sup>1-</sup> (aq) + H <sub>3</sub> O <sup>+</sup> (aq)	HSO <sub>4</sub> <sup>1-</sup>	1.0 x 10 <sup>3</sup>	1.0 x 10 <sup>-17</sup>
C <sub>5</sub> H <sub>5</sub> NH <sup>+</sup>	C <sub>5</sub> H <sub>5</sub> NH <sup>+</sup> (aq) + H <sub>2</sub> O (l) ↔ C <sub>5</sub> H <sub>5</sub> N (aq) + H <sub>3</sub> O <sup>+</sup> (aq)	C <sub>5</sub> H <sub>5</sub> N	5.9 x 10 <sup>-6</sup>	1.7 x 10 <sup>-9</sup>

2. Bases are proton **acceptors**. Complete the following chart for these **bases**:

Base	Ionization Reaction	Conjugate Acid	Ka	Kb
ClO <sup>-</sup>	ClO <sup>1-</sup> (aq) + H <sub>2</sub> O (l) ↔ HClO (aq) + OH <sup>-</sup> (aq)	HClO	4.0 x 10 <sup>-8</sup>	2.5 x 10 <sup>-7</sup>
N <sub>2</sub> H <sub>4</sub> (aq)	N <sub>2</sub> H <sub>4</sub> (aq) + H <sub>2</sub> O (l) ↔ N <sub>2</sub> H <sub>5</sub> <sup>+</sup> (aq) + OH <sup>-</sup> (aq)	N <sub>2</sub> H <sub>5</sub> <sup>+</sup>	7.7 x 10 <sup>-9</sup>	1.3 x 10 <sup>-6</sup>
CH <sub>3</sub> COO <sup>1-</sup>	CH <sub>3</sub> COO <sup>1-</sup> (aq) + H <sub>2</sub> O (l) ↔ CH <sub>3</sub> COOH (aq) + OH <sup>-</sup> (aq)	CH <sub>3</sub> COOH	1.8 x 10 <sup>-5</sup>	5.6 x 10 <sup>-10</sup>
HPO <sub>4</sub> <sup>2-</sup>	HPO <sub>4</sub> <sup>2-</sup> (aq) + H <sub>2</sub> O (l) ↔ H <sub>2</sub> PO <sub>4</sub> <sup>1-</sup> (aq) + OH <sup>-</sup> (aq)	H <sub>2</sub> PO <sub>4</sub> <sup>1-</sup>	6.2 x 10 <sup>-8</sup>	1.6 x 10 <sup>-7</sup>
F <sup>1-</sup>	F <sup>1-</sup> (aq) + H <sub>2</sub> O (l) ↔ HF (aq) + OH <sup>-</sup> (aq)	HF	6.3 x 10 <sup>-4</sup>	1.6 x 10 <sup>-11</sup>
H <sub>2</sub> O	H <sub>2</sub> O (l) + H <sub>2</sub> O (l) ↔ H <sub>3</sub> O <sup>+</sup> (aq) + OH <sup>1-</sup> (aq)	H <sub>3</sub> O <sup>+</sup>	1.0 x 10 <sup>-14</sup>	1.0
NH <sub>2</sub> OH	NH <sub>2</sub> OH (aq) + H <sub>2</sub> O (l) ↔ NH <sub>3</sub> OH <sup>+</sup> (aq) + OH <sup>-</sup> (aq)	NH <sub>3</sub> OH <sup>+</sup>	1.1 x 10 <sup>-6</sup>	8.8 x 10 <sup>-9</sup>
NH <sub>3</sub>	NH <sub>3</sub> (aq) + H <sub>2</sub> O (l) ↔ NH <sub>4</sub> <sup>+</sup> (aq) + OH <sup>-</sup> (aq)	NH <sub>4</sub> <sup>+</sup>	5.6 x 10 <sup>-10</sup>	1.8 x 10 <sup>-5</sup>
C <sub>5</sub> H <sub>5</sub> N	C <sub>5</sub> H <sub>5</sub> N (aq) + H <sub>2</sub> O (l) ↔ C <sub>5</sub> H <sub>5</sub> NH <sup>+</sup> (aq) + OH <sup>-</sup> (aq)	C <sub>5</sub> H <sub>5</sub> NH <sup>+</sup>	5.9 x 10 <sup>-6</sup>	1.7 x 10 <sup>-9</sup>
HCO <sub>3</sub> <sup>1-</sup>	HCO <sub>3</sub> <sup>1-</sup> (aq) + H <sub>2</sub> O (l) ↔ H <sub>2</sub> CO <sub>3</sub> (aq) + OH <sup>-</sup> (aq)	H <sub>2</sub> CO <sub>3</sub>	4.5 x 10 <sup>-7</sup>	2.2 x 10 <sup>-8</sup>

3. For nitrogen compounds, how can you recognize when they will behave as bases? As acids?

- if a nitrogen compound is uncharged (neutral), it will probably behave as a base
- if a nitrogen compound is positively charged, it will probably behave as an acid

4. As a general rule for weak acids and bases, negative ions in solution will behave as **bases**.

5. Using your knowledge of trends for acid strengths, arrange the following acids in order from highest to lowest strength:

HI is the strongest (it is closest to the bottom of the Periodic table),

HCl is the only other strong acid so it comes next

H<sub>3</sub>PO<sub>4</sub> is a weak acid, but it is stronger than H<sub>3</sub>PO<sub>3</sub> because it has more O atoms

H<sub>3</sub>PO<sub>3</sub> is the weakest of these acids

6. Using K<sub>a</sub> values, arrange the following acids in order from highest to lowest strength:

strongest:	H <sub>2</sub> SO <sub>3</sub>	(K <sub>a</sub> = 1.4 × 10 <sup>-2</sup> )
	H <sub>3</sub> PO <sub>4</sub>	(K <sub>a</sub> = 6.9 × 10 <sup>-3</sup> )
	HF	(K <sub>a</sub> = 6.3 × 10 <sup>-4</sup> )
	HNO <sub>2</sub>	(K <sub>a</sub> = 5.6 × 10 <sup>-4</sup> )
	HCH <sub>3</sub> COO	(K <sub>a</sub> = 1.8 × 10 <sup>-5</sup> )
	H <sub>2</sub> CO <sub>3</sub>	(K <sub>a</sub> = 4.5 × 10 <sup>-7</sup> )
weakest:	H <sub>2</sub> S	(K <sub>a</sub> = 8.9 × 10 <sup>-8</sup> )

7. Which of the acids in Q6 has the strongest conjugate base? H<sub>2</sub>S has the strongest conjugate base, HS<sup>-</sup>

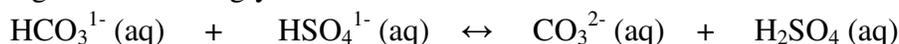
8. Calculate the pH of the following solutions:

- a) 15.4 g of potassium hydroxide in 600.0 mL of distilled water (13.660, 3 decimal places)  
 b) 125 mL of 15.0 M of nitric acid diluted to 1.00 litre of solution (-0.273, 3 decimal places)  
 c) a 0.0125 M solution of magnesium hydroxide (12.398, 3 decimal places)  
 d) a 1.35 M solution of acetic acid (2.31, 2 decimal places from K<sub>a</sub>)  
 e) a 2.00 M solution of pyridine (C<sub>5</sub>H<sub>5</sub>N) (9.77, 2 decimal places from K<sub>b</sub>)  
 f) 0.555 M solution of hypobromite ion (from sodium hypobromite) (11.15, 2 decimals from K<sub>a</sub>)  
 g) 100.0 mL of 18.0 M H<sub>2</sub>SO<sub>4</sub> diluted to 500.0 mL of solution (-0.556, 3 decimal places)

9. Complete the following chart. Include the correct number of sig digs in your answers:

pH	pOH	[H <sub>3</sub> O <sup>+</sup> ]	[OH <sup>-</sup> ]	acid/base/neutral
1.25	12.75	5.6 × 10 <sup>-2</sup>	1.8 × 10 <sup>-13</sup>	acid
9.334	4.666	4.63 × 10 <sup>-10</sup>	2.16 × 10 <sup>-5</sup>	base
4.90	9.10	1.3 × 10 <sup>-5</sup>	7.9 × 10 <sup>-10</sup>	acid
13.875	0.125	1.33 × 10 <sup>-14</sup>	0.750	base
9.00	5.00	1.0 × 10 <sup>-9</sup>	1.0 × 10 <sup>-5</sup>	base

10. The following reaction strongly favours the reactants:



- a) the strongest acid in this system is: **H<sub>2</sub>SO<sub>4</sub> (aq)**  
 b) the strongest base in this system is: **CO<sub>3</sub><sup>2-</sup> (aq)**  
 c) Will this reaction have a large or small value of K<sub>eq</sub>? Explain.
  - the K<sub>eq</sub> for this reaction will be very small in the forward direction. Because the products of the reaction include a very strong acid and strong base (the conjugate of a weak acid), these species will tend to drive the reaction strongly in reverse. There will be very little product formed, so the value of K<sub>eq</sub> will be much less than one.

11. The pH of a 0.16 M solution of phenolic acid is 3.20.

- a) What is the  $K_a$  for phenolic acid? ( $K_a = 2.5 \times 10^{-6}$ )  
 b) What is the percent dissociation of the acid in this solution? (only 0.39% dissociated)

12. Name the following substances and then predict whether their solutions will be acidic, basic or neutral:

- a)  $\text{NaCH}_3\text{COO}$ : sodium acetate, basic  
 b)  $\text{NH}_4\text{Cl}$ : ammonium chloride, acidic  
 c)  $\text{Li}_2\text{O}$ : lithium oxide, basic  
 d)  $\text{Sr}(\text{NO}_3)_2$ : strontium nitrate, neutral  
 e)  $\text{HBrO}$  ( $\text{HOBr}$ ): hypobromous acid, acidic  
 f)  $\text{CoBr}_2$ : cobalt (II) bromide, acidic  
 g)  $\text{Cr}(\text{NO}_3)_2$ : chromium (II) nitrate, acidic  
 h)  $\text{Na}_3\text{PO}_4$ : sodium phosphate, basic  
 i)  $\text{HSCN}$ : thiocyanic acid, acidic  
 j)  $\text{CaC}_2\text{O}_4$ : calcium oxalate, basic  
 k)  $\text{Mg}(\text{ClO}_3)_2$ : magnesium chlorate, neutral  
 l)  $\text{K}_3\text{BO}_3$ : potassium borate, basic  
 m)  $\text{SnCl}_4$ : tin (IV) chloride, acidic

13. What are two tests or properties you could distinguish between the following solutions?

- a)  $\text{NaCl}$  and  $\text{NaClO}$ : sodium chloride is a neutral salt while sodium hypochlorite is a basic salt

Test	$\text{NaCl}$ solution	$\text{NaClO}$ solution
skin feel	watery	slippery
colour with phenolphthalein	colourless	pink
colour with bromothymol blue	green	blue
colour with red litmus	red	blue

- b)  $\text{H}_2\text{O}$  and  $\text{Li}_2\text{O}$ : water is neutral and covalent while lithium oxide will form a base in solution

Test	$\text{H}_2\text{O}$ solution (liquid)	$\text{Li}_2\text{O}$ solution
skin feel	watery	slippery
colour with phenolphthalein	colourless	pink
colour with bromothymol blue	green	blue
colour with red litmus	red	blue
conductivity	non-electrolyte	electrolyte

- c)  $\text{HClO}_2$  and  $\text{HClO}_3$ : both of these solutions are acids, but  $\text{HClO}_2$  is a weak acid while  $\text{HClO}_3$  is strong

Test	$\text{HClO}_2$ solution	$\text{HClO}_3$ solution
conductivity	weak electrolyte	strong electrolyte
pH (use same concentration of both solutions, eg. 1.0M of each)	pH of $\text{HClO}_2$ will be higher than pH of $\text{HClO}_3$	pH of $\text{HClO}_3$ will be lower than pH of $\text{HClO}_2$
rate of reaction with a metal	weak acid so reaction will be slow because the $[\text{H}_3\text{O}^+]$ is low	strong acid so reaction will be fast because the $[\text{H}_3\text{O}^+]$ is high
rate of reaction with a carbonate	weak acid so reaction will be slow because the $[\text{H}_3\text{O}^+]$ is low	strong acid so reaction will be fast because the $[\text{H}_3\text{O}^+]$ is high

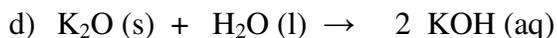
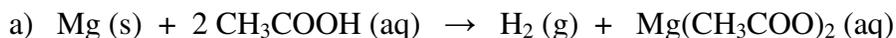
13d)  $\text{H}_2\text{S}$  and  $\text{Na}_2\text{S}$  : in solution,  $\text{H}_2\text{S}$  is a weak acid and  $\text{Na}_2\text{S}$  is a basic salt

Test	$\text{H}_2\text{S}$ solution	$\text{Na}_2\text{S}$ solution
skin feel	watery	slippery
pH	less than 7.0	greater than 7.0
colour with phenolphthalein	colourless	pink
colour with bromothymol blue	yellow	blue
colour with red litmus	red	blue
colour with blue litmus	red	blue
reaction with metals	produce $\text{H}_2$ gas	no reaction
reaction with carbonates	produce $\text{CO}_2$ gas	no reaction

e)  $\text{Ca}(\text{OH})_2$  and  $\text{Co}(\text{OH})_2$ : both solutions are bases, but  $\text{Ca}(\text{OH})_2$  is a strong base and  $\text{Co}(\text{OH})_2$  is weak

Test	$\text{Ca}(\text{OH})_2$ solution	$\text{Co}(\text{OH})_2$ solution
conductivity	strong electrolyte	weak electrolyte
pH (use same concentration of both solutions, eg. 1.0M of each)	pH of $\text{Ca}(\text{OH})_2$ will be higher than pH of $\text{Co}(\text{OH})_2$	pH of $\text{Co}(\text{OH})_2$ will be lower than pH of $\text{Ca}(\text{OH})_2$

14. Write the products of the following reactions (if any) and then balance each reaction:



#### Answers to Multiple Choice Questions:

1. a	14. a	27. b	40. c	53. d
2. c	15. b	28. d	41. b	54. d
3. c	16. c	29. d	42. c	55. d
4. b	17. a	30. c	43. a	56. a
5. b	18. d	31. a	44. c	57. b
6. c	19. c	32. d	45. d	58. d
7. a	20. a	33. c	46. b	59. d
8. d	21. c	34. c	47. d	60. a
9. b	22. a	35. b	48. b	61. a
10. a	23. c	36. a	49. c	62. d
11. a	24. d	37. c	50. a	63. a
12. c	25. a	38. b	51. b	64. d
13. c	26. a	39. a	52. a	65. c

66. d 67. b